

History and Discovery of Asteroids

What CAN You See With a Telescope?

FLASHBACK—ASTRONOMY WITH A TELESCOPE

Ceres¹, Pallas², Juno², and Vesta² the largest and brightest asteroids, were the first four asteroids discovered. They were found between 1801 and 1807. Scientists thought that there were more asteroids to be found, so groups of amateur and professional astronomers designed special sky-mapping projects to search for them. But no more asteroids were found until almost forty years later, in 1845.

Scientific experimental design is not always successful

A Lull in Asteroid Discovery

Why were no new asteroids found during this period? Simply put, most of them were too small and too dim to be easily observed through the early 19th-century telescopes. Remember that many of the early asteroid discoverers were amateur astronomers using very basic equipment. And they were looking for asteroids that were much smaller and/or dimmer than the four principal asteroids that had already been found. Even when the four largest asteroids were seen through those early telescopes, they appeared only as points of reflected sunlight³. They looked very much like the countless stars around them, except that they moved. So it was difficult to find a moving point of light in a sky full of stars.



Can you find the asteroid amidst all these stars? The faint streak in the center is the trail left by a moving asteroid. This one, captured by the Palomar Digital Sky Survey, is asteroid 1999 AN10.

Size was a Factor in Asteroid Discovery

Most asteroids are longer than they are wide. Ceres, the largest asteroid, measures about 960 km at its longest axis. Pallas is about 574 km long. Vesta is about half the size of Ceres, being about 560 km in length. Juno, the smallest of the principal four, is approximately 190 km long.

In 1802, **William Herschel**⁴ attempted to measure the sizes of both Ceres and Pallas. He looked at each asteroid through a telescope while comparing them to a small disk of a known size at a given distance. Herschel's values were 259 km for Ceres and 236 km for Pallas. These were considerably smaller than the modern measurements given above.

Most of the asteroids discovered between 1845 and 1890 were much smaller than the first asteroids found. They range in size between 80 and 130 km. Hygiea, with a diameter of about 410 km, is an exception; however, it is dimmer than any of the first asteroids found. Only about 30 asteroids with diameters greater than 200 km have been found. It is estimated that there are 250 asteroids larger than 100 km in diameter. There are about 1,000,000 asteroids with diameters greater than 1 km.

Quantitative measurements give us different information than qualitative observation.

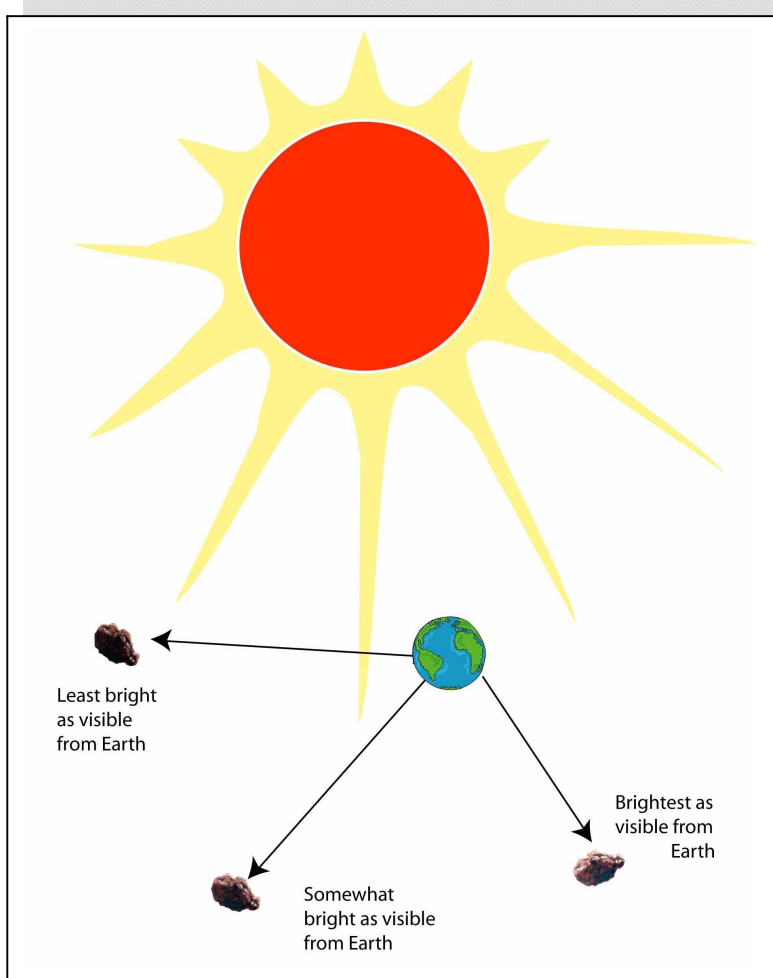
Asteroid Brightness -- Another Factor to Consider

So, the size of the vast majority of asteroids is quite small, but that is not the whole story. An asteroid's brightness varies according to several factors: how far away it is from the Sun, and how far it's reflected light has to travel to reach the Earth. Furthermore, most asteroids have very irregular shapes. Their brightness also depends upon which part of their surface faces the sun and how much light is reflected from that particular surface. Scientists use the term **albedo** to describe how much light is reflected.

The table below shows the *brightness* of the first ten asteroids when they are brightest as seen from Earth. Brightness is measured on a scale in which the larger the value of an asteroid's brightness, the dimmer the asteroid appears to an observer on Earth. Notice that Ceres and Vesta have almost the same brightness. They are 4.0 and 4.2 on the brightness scale respectively. However, they are quite different in size, in distance from the Earth, albedo, and in how much light they reflect.

8. Ceres is about twice the size of Vesta.
9. Vesta comes slightly closer to Earth than Ceres does as they orbit around the sun.

10. Vesta's surface reflects four times more light than Ceres' surface.



Asteroid Number	Year of Discovery	Asteroid Name	Asteroid Brightness	Asteroid Number	Year of Discovery	Asteroid Name	Asteroid Brightness
1	1801	Ceres	4.0	6	1847	Hebe	8.5
2	1802	Pallas	5.1	7	1847	Iris	8.4
3	1804	Juno	6.3	8	1847	Flora	9.0
4	1807	Vesta	4.2	9	1848	Metis	9.8
5	1845	Astraea	6.6	10	1849	Hygeia	6.4

Asteroids are now numbered in the order in which they were discovered. Can see that the relative brightness of the first four asteroids may have been a factor in their early discovery? Even Ceres, the brightest asteroid, is only a moderately bright star when seen through a telescope! Most asteroids are so dim that they look like faint stars.

To put these asteroid brightness measurements into perspective, the Sun has an apparent magnitude of -27; the Moon, -12; Venus, -4; and the brightest stars, -1. An object of approximately the 6th magnitude, like Juno, is barely visible to a person with good eyesight on a clear, moonless night. With a good set of binoculars, one

Limitations of technology

can see objects down to the 10th magnitude. With an 8-inch reflecting telescope an observer can manage to see objects of 14th magnitude on very dark nights⁵. The faintest objects detectable with today's largest ground-based telescopes are about magnitude 30.

Rotation Rates Influence Asteroid Brightness

Early astronomers had used their telescopes to measure the **rotation rate** of the Sun and some of the planets. Since the asteroids were thought to be “minor planets,” it was assumed that they also rotated on their own axes. In 1810, Schröeter⁶ thought Juno had a 27-hour rotation rate. This is about four times the current value of 7.21 hours.

An asteroid's rotation rate is determined by measuring the short-period variations in brightness. As an asteroid rotates on one of its axes, its irregularly shaped body and the different albedos of its reflecting surfaces cause changes in brightness. For asteroids, these variations are small. Some are as small as a few hundredths to 0.4 of a magnitude. This makes it difficult to detect except under ideal conditions.

So, the only asteroid features that early 19th-century astronomers could observe with their telescopes were dependent upon the brightness and the variations in brightness of their reflected light. Remember these asteroids appeared only as points of light through the telescopes available during that time period. Obviously they could not see any surface feature details of even Ceres or Vesta, the largest and the brightest of them all.

¹ see “It Was a Dark and Starry Night” vignette

² see “Astronomical Serendipity” vignette

³ see “Of Glass and Light”

⁴ see Astronomical Serendipity” vignette

⁵ see http://www.geocities.com/catskills_astronomy_club/darksky.htm.

⁶ see “Astronomical Serendipity” vignette

Additional Resources

For more information about the history of the brightness scale, go to:

http://www.astro.virginia.edu/~teacha/130_manual/node30.html or
http://www.astro-tom.com/technical_data/magnitude_scale.htm)

<http://www.astro.uu.se/planet/asteroid/shapes/>

This interactive allows the user to rotate irregular-shaped asteroids to see how they would look in 3-D.

<http://near.jhuapl.edu/NEAR/Voyage/img/lcurve3.mpg>

This animation shows the brightness variations of asteroid Eros during its rotation. Observe closely or you may miss this flashing point of light.

Questions relating to What Can You See with a Telescope?

1. How long after Vesta was discovered in 1807 was the next asteroid found? What was its name? Why was there a lull in asteroid discoveries between 1807 and 1845?
2. How does Astraea's brightness compare with that of Ceres? Explain which of these asteroids is the brightest and why.
3. What factors affect how much sunlight asteroids reflect to observers on Earth?
4. Define albedo, in your own words.

5. In the asteroid names, 1 Ceres and 5 Astraea, what do the numbers stand for?
6. Herschel attempted to measure the size of Ceres and Pallas. Schröeter tried to measure the rotation rate of Juno. How accurate were these early measurements?
7. One person tells you that it is a long way to the next large city. Another person says that it is 150 miles to the next large city. Which of these statements includes a quantitative measurement and which is a qualitative observation? Which gives you the most precise information?
8. Why do you think that it is important that astronomers are able to make quantitative measurements? What kept the early astronomers from making reliable quantitative measurements?
9. What asteroid features could 19th century astronomers observe through their telescopes?